REMARKS

This amendment is submitted in reply to the Office Action mailed on August 29, 2001. The Office Action rejects Claims 1, 4, 6, and 9 under 35 U.S.C. § 112, second paragraph; Claims 1-10 and 14-17 under 35 U.S.C. § 102(b); Claims 11-13 under 35 U.S.C. § 103(a); objects to the drawings under 37 C.F.R. 1.83(a); and objects to the specification as to informalities.

Claims 1-17 are pending in this application. Claims 1, 4, 6, 9 and 16 have been amended to better clarify the claimed invention. Claims 2, 5, 7 and 10 have been canceled. New Claims 18, 19, 20, 21 and 22 have been added.

As a preliminary matter, the drawings are objected to under 37 C.F.R. 1.83(a). The Examiner states that the drawings fail to show the illustration of reference elements 1, 2, 3, 3-1 – 3-n in reference to Fig. 23 as described in the specification in the last paragraph of page 2. Applicants have amended the drawings to remove the objectionable material. No new matter has been added. Therefore, the objection as to the drawings is now believed to be moot.

As a further preliminary matter, the Examiner also objects to informalities in the specification. The Examiner states that on page 3, line 8 of the specification, the heading "Disclosure of the Invention" should be changed to "Summary of the Invention." Applicants have amended the specification to change the heading. No new matter has been added. Therefore, the objection as to the specification is now believed to be moot.

Claims 1, 4, 6, and 9 stand rejected under 35 U.S.C. § 112, second paragraph, as being incomplete for omitting essential elements. The Examiner states that the omitted elements relate to control means or control steps. Specifically, the Examiner states that Claims 1 and 6 do not include a control element or control means in the limitations of Claims 1 and 6. Furthermore, the Examiner states that Claims 4 and 9 are incomplete for omitting a controlling step.

Applicants have amended Claims 1, 4, 6, and 9 to include the control means or control step claimed in Claims 2, 5, 7 and 10, respectively. Claims 2, 5, 7 and 10 have been canceled. Based on the amendments to the claims, Applicants respectfully request that the rejections of Claims 1, 4, 6, and 9 under 35 U.S.C. § 112, second paragraph, be withdrawn.

Claims 1-10 and 14-17 stand rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 4,807,153 ("*Onaga et al.*"). Applicant submits that the reference does not, in fact, disclose all the limitations in Claims 1-10 and 14-17 of the claimed invention. Thus, Applicant respectfully requests that the patentability of these claims be reconsidered for the following reasons.

The claims of the instant patent application, as amended, disclose a robot joint mechanism control device having an actuator or motor (i.e. M-1 through M-14) that includes electric current detection means, torque detection means and control means. *See* the specification on page 18, lines 9-18, and Figs. 9 and 19. The advantage of including the control means inside the actuator (i.e. the electric current detection means and the torque detection means) is that the robot becomes more compact because less external control components are required and the robot is manufactured with fewer wires. The more compact the robot is, the more maneuverable the robot becomes in operation.

Additionally, the wires in the robot that connect the various motors to each other and to a main control panel are prone to tear or break during movement of the robot joints. In particular, the wires in the arms of a robot are subject to greater stresses than other parts of the robot because the arms rotate in several directions and move more frequently than the other parts. As a result, the claimed invention reduces the likelihood of a wire tearing or breaking in a robot

because the control means are located inside each motor and therefore, less wires are needed to connect the various components of the robot.

On the contrary, *Onaga et al.* controls the joint movement in robots using a complex system that includes extensive wiring between control components. *Onaga et al.* uses sensors to detect motor current feedback in the power switch circuitry. *See* Col. 7, lines 60-64 and Fig. 5. A servo control board 400 and a Torque Processor (TP) board, which are independent and external from the robot joints, are used to control the motors on the robot arm based on the motor current feedback. *See* Fig. 4.

The servo control board 400 develops position commands for each robot axis on the arm. *See* Col. 7, lines 38-41. After the position commands from the servo control board 400, the torque processor (TP) board 600 generates the voltage commands for each joint motor. *See* Col. 7, lines 42-48. The voltage commands are delivered to the motors on the arm to change the position or move the arm. Because the control means, i.e. the servo control board 400 and the torque processor board 600, are external to the robot arm in *Onaga et al.*, complex wiring must be used to connect these components to the motors to control the motors. Thus, more wires and external control equipment are required to operate the robot arm in *Onaga et al.* than in the claimed invention. These features prevent the robot from being compact and also increases the likelihood that a wire will tear or break during operation of the robot joints.

Therefore, *Onaga et al.* does not disclose an actuator or motor that includes control means such as the electric current detection means and external force torque detection means as in the claimed invention. Instead, the cited reference uses control boards that are external from the joint motors to detect the electric current and to control the torque in the motors.

Thus, Applicants respectfully submit that independent Claims 1, 4, 6, 9, 14 and 16, and dependent Claims 2-3, 5, 7-8, 10, 15 and 17, are novel over the art of record because the *Onaga et al.* reference does not disclose all of the limitations of the claimed invention.

Claims 11-13 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over *Onaga et al.* Applicants submit that the *Onaga et al.* reference does not, in fact, teach or suggest all of the limitations in Claims 11-13. Thus, Applicants respectfully request that the patentability of these claims be reconsidered for the following reasons.

Similar to the discussion above, independent Claim 11 has been amended to disclose an actuator or motor that contains control means (i.e. electric current detection means and external force torque detection means) that controls the position of the actuator. By including the control means in the motor, less wiring is required and the robot joints and overall robot configuration can be a compact design.

Conversely, *Onaga et al.* employs external motor controls that are not inside the motors themselves. As a result, the controls in *Onaga et al.* require complex connections and wiring which increases the size of the robot joints and robot, and increases the chances for a wire to tear or break during operation. Thus, *Onaga et al.* does not teach or suggest the claimed invention and the rejection of Claim 11-13 should be withdrawn.

Moreover, newly added Claims 18-22 are also novel over the art of record. Claims 18 and 19 disclose a control apparatus and robot apparatus, respectively, that specifically includes motors having motor cases that include the control means for controlling the position of the robot joints. The *Onaga et al.* reference, however, uses external control components and complex wiring to control the joint movements, which are not inside the joint motors themselves.

Claims 20 and 21 disclose a robot apparatus including a memory, and control means having electric current detection means and external force torque detection means. The external force torque is calculated by subtracting the preliminary stored torque, or self-weight torque, from the output torque of each motor. *See* the specification on page 39, lines 13-25. The preliminary stored torque is the torque generated by the weights on the output axis of each motor at the time of each posture, and may be stored in a memory device in advance. Calculating the external torque in this manner enables the external force torque to be calculated more precisely and therefore, control of the robot joints is substantially more accurate.

On the contrary, the motor torque in *Onaga et al.* is simply calculated from the drive current thus, providing less accurate control over the motion of a robot joint. *Onaga et al.* does not disclose or suggest a robot apparatus that calculates the external force torque in the manner disclosed by the claimed invention.

In light of the above, Applicants respectfully submit that Claims 1-17 are both novel and non-obvious over the art of record because *Onaga et al.* does not disclose, teach or suggest all of the limitations of the claimed invention. Accordingly, Applicants respectfully request that Claims 1-17, as amended, as well as newly added Claims 18-22, be deemed allowable at this time and that a timely Notice of Allowance be issued in this case.

Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The attached page is captioned "**Versions with Markings to Show Changes Made.**"

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the Specification:

Paragraph beginning at line 19 of page 2 has been amended as follows:

With the conventional 2-leg walking robot, for example, as shown in Fig. 23, a main control unit (not shown) ~~1~~ for controlling the operations of the entire robot is connected to each motor 3 (3-1 through 3-n) through a multi-axis controller 2, and the multi-axis controller 2 controls each motor 3 in each specific state at a control instruction output from the main control unit ~~1~~.

Paragraph beginning at line 1 of page 3 has been amended as follows:

In the above described two-leg walking robot, three rotation drive cables (U phase, V phase, and W phase), four rotation position sensor cables (A phase, B phase, and Z phase), and one ABS position serial signal cable, that is, a total of seven cables ~~4,~~ are required, thereby causing the problem of a ~~complicate~~ complicated configuration containing a larger number of wires for the entire robot.

The heading at page 3, line 8 has been amended as follows:

~~Disclosure of the Invention~~ Summary of the Invention

Paragraph beginning at line 19 of page 7 has been amended as follows:

Figs. ~~4(a) and 4(b)~~ 4(A) and 4(B) are a front view and a side view respectively, showing the configuration of the thigh joint mechanism.

Paragraph beginning at line 21 of page 7 has been amended as follows:

Figs. ~~5(a) and 5(b)~~ 5(A) and 5(B) are a front view and oblique view, respectively, showing the configuration of the thigh joint mechanism.

Paragraph beginning at line 23 of page 7 has been amended as follows:

Figs. ~~6(a), 6(b) and 6(c)~~ 6(A), 6(B) and 6(C) are a side view, a front view and a side view, respectively, showing the configuration of the ankle joint mechanism.

Paragraph beginning at line 7 of page 8 has been amended as follows:

Figs. ~~10(a), 10(b) and 10(c)~~ 10(A), 10(B) and 10(C) show the outline of the configuration of the rotor and the rotor axis magnetic pole angle sensor.

Paragraph beginning at line 11 of page 8 has been amended as follows:

Figs. ~~12(a), 12(b) and 12(c)~~ 12(A), 12(B) and 12(C) show the outline of the configuration of a stator and a power substrate.

Paragraph beginning at line 13 of page 8 has been amended as follows:

Figs. ~~13(a), 13(b) and 13(c)~~ 13(A), 13(B) and 13(C) show the outline of the configuration of a torque amplification unit.

Paragraph beginning at line 20 of page 8 has been amended as follows:

Figs. ~~16(a) and 16(b)~~ 16(A) and 16(B) are plan views showing the outline of the configuration of the control substrate.

Paragraph beginning at line 9 of page 9 has been amended as follows:

Fig. 23 is a block diagram showing the connection relationship between each motor <u>of</u> ~~and the main control unit of~~ the conventional robot.

Paragraph beginning at line 19 of page 11 has been amended as follows:

Figs. ~~4 and 5~~ <u>4(A), 4(B), 5(A) and 5(C)</u> show the configuration of the thigh joint mechanism 36 of the robot 10, and Fig<u>s</u>. 6<u>(A), 6(B) and 6(C)</u> show~~s~~ the configuration of the ankle joint mechanism 43.

Paragraph beginning at line 22 of page 11 has been amended as follows:

As shown in Figs. ~~4 and 5~~ <u>4(A), 4(B), 5(A) and 5(B)</u>, the motor M-9 is fixed to the hip base 21 at the lower portion of the belly unit in the thigh joint mechanism 36. The output axis of the motor M-10 is connected to the output axis of the motor M-9 through a U-shaped connection material 50, and a U-shaped material 51 is fixed to the side of the motor M-10.

<u>In the Claims:</u>

Claim 1 has been amended as follows:

1. (Amended) A joint ~~mechanism~~ control apparatus ~~having an actuator~~ for <u>controlling the movement of a robot joint, which includes a first link and a second link where the first link is rotated about</u> ~~generating rotation torque whose level depends on a drive current, connecting a first link to a second link as freely rotating on~~ a predetermined axis ~~, and rotating the first link on the predetermined axis based on the rotation torque~~ <u>with torque generated by the</u>

apparatus, said apparatus ~~output from the actuator through an output axis of the actuator,~~ ~~characterized by~~ comprising:

an actuator;

electric current detection means included in said actuator for detecting ~~an electric current value of the~~ a drive current of the actuator; ~~and~~

~~external force~~ torque detection means included in said actuator for detecting ~~a level~~ the amount of ~~a~~ torque ~~by an external force applied to the output axis of the actuator~~ based on the ~~electric current value~~ drive current detected by said electric detection means; and

control means included in said actuator for controlling the actuator based on the amount of torque detected by said torque detection means.

Claim 2 has been canceled.

Claim 3 has been amended as follows:

3. (Amended) The joint ~~mechanism~~ control apparatus according to Claim 1, ~~characterized in that: said~~ wherein the actuator ~~comprises~~ includes:

a motor unit ~~generating the rotation~~ that generates the torque depending on a supplied drive current;

a torque amplification unit ~~amplifying~~ that amplifies the ~~rotation~~ torque generated by said motor unit, and transmits the torque to ~~said output axis~~ the actuator; and

motor control means included in said motor unit for controlling said motor unit by supplying said motor unit with ~~the~~ a level of drive current ~~at a level according to~~ based on externally provided control information ~~and~~

~~said motor control unit is provided in said motor unit~~.

Claim 4 has been amended as follows:

4. (Amended) A joint ~~mechanism~~ control method ~~having an actuator~~ for controlling the movement of a robot joint in which the joint includes a first link and a second link where the first link is rotated about ~~generating a rotation torque whose level depends on a drive current, connecting a first link to a second link as freely rotating on~~ a predetermined axis ~~, and rotating the first link on the predetermined axis based on the rotation~~ with torque generated by the apparatus, said method including: ~~output from the actuator through an output axis of the actuator, characterized by comprising:~~

a first step of detecting ~~an electric current value of the~~ a drive current of the actuator using an electric current detection means included in the actuator; ~~and~~

a second step of detecting ~~a level~~ an amount of torque ~~by an external force applied to the output axis of the actuator~~ based on the drive current detected by the electric current detection means ~~electric current value~~ using torque detection means included in the actuator; and

a third step of controlling the actuator using control means based on the amount of torque detected in said second step.

Claim 5 has been canceled.

Claim 6 has been amended as follows:

6. (Amended) A robot device including a joint ~~mechanism~~ control apparatus ~~having an actuator~~ for controlling the movement of the joint, which includes a first link and a

second link where the first link is rotated about a predetermined axis ~~based on the rotation torque~~ with torque generated by the apparatus, said apparatus ~~output from the actuator through an output axis of the actuator, characterized by~~ comprising:

an actuator;

electric current detection means included in said actuator for detecting ~~an electric current value of the~~ a drive current of the actuator; ~~and~~

~~external force~~ torque detection means included in said actuator for detecting ~~a level~~ the amount of ~~a~~ torque ~~by an external force applied to the output axis of the actuator~~ based on the drive current ~~electric current value~~ detected by said electric current detection means; and

control means included in said actuator for controlling the actuator based on the amount of torque detected by said torque detection means.

Claim 7 has been canceled.

Claim 8 has been amended as follows:

8. (Amended) The robot device according to Claim 6, ~~characterized in that:~~

~~said~~ wherein the actuator ~~comprises~~ includes:

a motor unit ~~generating the rotation~~ that generates the torque depending on a supplied drive current;

a torque amplification unit ~~amplifying~~ that amplifies the ~~rotation~~ torque generated by said motor unit, and transmits the torque to ~~said output axis~~ the actuator; and

motor control means included in said motor unit for controlling said motor unit by supplying said motor unit with ~~the~~ a level of drive current ~~at a level according to~~ based on externally provided control information ~~, and~~

~~said motor control means is provided in said motor unit~~.

Claim 9 has been amended as follows:

9. (Amended) A robot device control method having a joint mechanism for controlling the movement of a the joint, which includes a first component and a second component where the first component is rotated about ~~including an actuator for generating a rotation torque whose level depends on a drive current, connecting a first component to a second component as freely rotating on~~ a predetermined axis ~~, and rotating the first component on the predetermined axis based on the rotation~~ with torque that is output from the actuator through an output axis of the actuator, comprising:

a first step of detecting an electric current value of the drive current of the actuator using electric current detection means included in the actuator; ~~and~~

a second step of detecting a level of a torque created by an external force applied to the output axis of the actuator based on the detected electric current value using control means included in said actuator; and

a third step of controlling the actuator using control means included in said actuator such that the torque created by the external force applied to the output axis of the actuator can be removed based on a detected result obtained in said second step.

Claim 10 has been canceled.

Claim 11 has been amended as follows:

11. (Amended) A robot device having a pair of leg units in each of which a lower leg unit is connected to a thigh unit through a knee joint mechanism, and a foot unit connected to the lower leg unit through an ankle joint mechanism, said pair of leg units being driven in a predetermined pattern such that a walking operation is performed wherein said foot units of said leg units ~~are~~ alternately touch a walking path on which the robot device is placed ~~such that a walking operation can be performed with the leg units are driven in a predetermined pattern, characterized by~~ said robot device comprising :

an actuator, provided in said ankle joint mechanism, generating a rotation torque whose level depends on a drive current for rotation-driving said foot unit on a predetermined axis;

electric current detection means included in said actuator for detecting an electric current value of the drive current of the actuator; ~~and~~

~~external force~~ torque detection means included in said actuator for detecting a level of ~~a~~ torque created by an external force applied to the output axis of the actuator based on the electric current value detected by said electric current detection means; and

control means included in said actuator for controlling the actuator based on a detection result from said ~~external force~~ torque detection ~~unit~~ means such that the external force applied to the output axis of the actuator can be removed.

Claim 12 has been amended as follows:

12. (Amended) The robot device according to Claim 11, ~~characterized in that:~~

an external force applied to the output axis of the actuator based on the detected electric current value; and

a third step of controlling the actuator using control means included in said actuator, based on a detection result obtained in said second step, such that the external force applied to the output axis of the actuator can be ~~removed~~ counteracted.

Claim 14 has been amended as follows:

14. (Amended) A joint device in which a first link ~~is~~ connected to a second link ~~as~~ is freely ~~rotating~~ rotatable about ~~on~~ a predetermined axis, the joint device comprising

an actuator generating rotation torque for rotation-driving said first link about ~~on~~ said predetermined axis, ~~characterized in that~~

said actuator comprises:

a motor unit generating the rotation torque; and

motor control means included in said motor unit for controlling the ~~drive of~~ rotation torque output from said motor unit~~; and~~

~~said motor control means is provided in said motor unit~~.

Claim 16 has been amended as follows:

16. (Amended) A robot device having a joint mechanism in which a first component is connected to a second component ~~as~~ in a freely rotating manner about on a predetermined axis, ~~comprising:~~ and

an actuator generating a rotation torque for ~~rotation drive~~ rotation-driving said first component ~~on~~ about the predetermined axis, ~~wherein~~ said actuator ~~comprises~~ comprising:

a motor unit generating the rotation torque; and

motor control means included in said motor unit for controlling the ~~drive of~~ rotation torque output from said motor unit ~~characterized in that said motor control means is provided in said motor unit~~.